

The Cold Air Aloft Problem: Applications of Temperature Soundings in High Latitude Regions for Aviation

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BACKGROUND

- Cold Air Aloft (CAA; -65°C and below) is potentially hazardous to aircraft due to the threat of fuel crystalizing or freezing at these extreme temperatures
- The Anchorage, Alaska Center Weather Service Unit (CWSU; Fig. 1) provides Meteorological Impact Statements (MIS; Fig. 2) to Air Traffic Controllers to direct flights around CAA regions

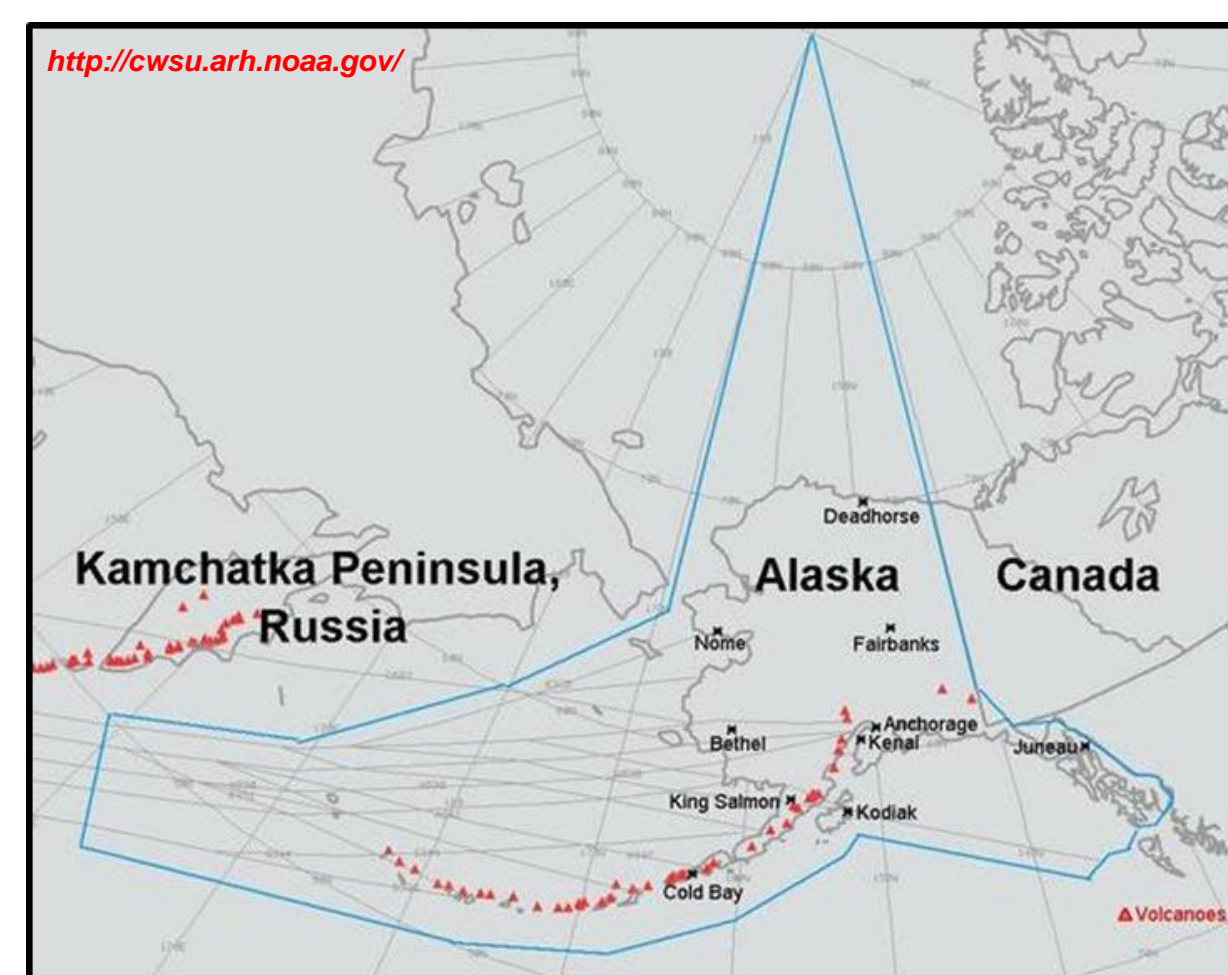


Fig. 1. Anchorage, AK CWSU domain

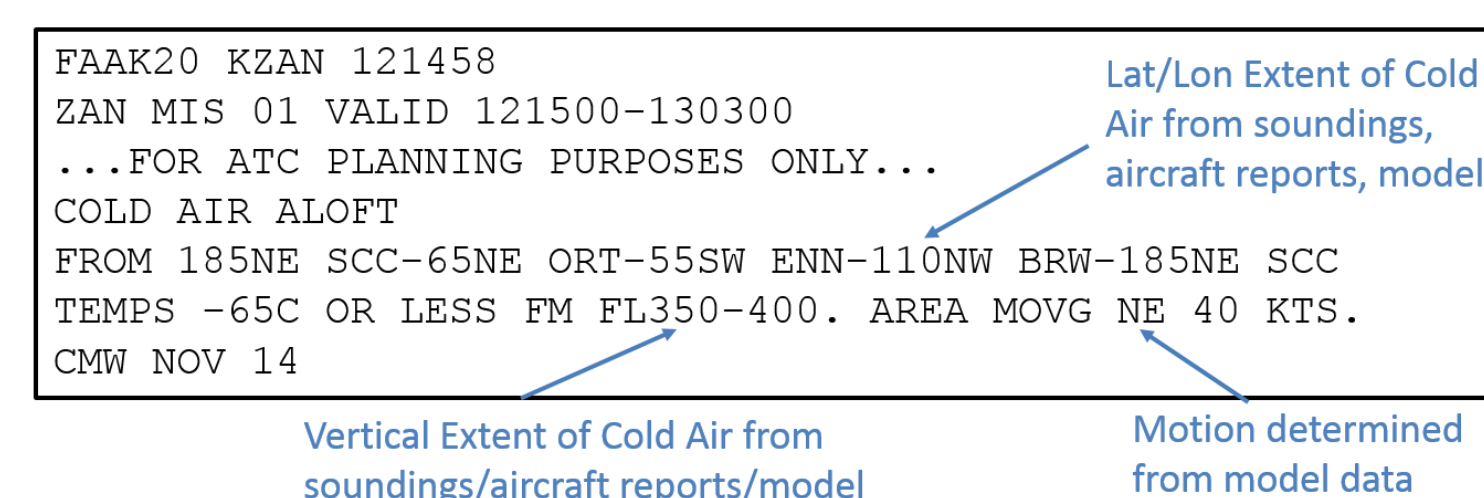


Fig. 2. Sample MIS product issued by CWSU defining the 3D extent of potentially hazardous cold air.

- In data sparse Alaska, forecasters traditionally rely on analysis/model fields, limited radiosonde observations, and pilot reports to guess the 3D extent of the CAA
- Forecasters at the CWSU have expressed the need for an observational product from satellites that can be used to supplement model output
- Use of hyperspectral IR soundings, such as those from the Cross-track Infrared Sounder (CrIS), may allow forecasters to observe the 3D extent of CAA in real-time where conventional observations are lacking

DETECTION OF CAA FEATURES FROM HYPERSPECTRAL IR

- CAA features are observed at typical flight levels (around 200 hPa) in the sounder data at relatively high frequencies during the winter months in the Northern Hemisphere (Fig. 3); distribution and frequency compares well to reanalysis climatology (not shown)
- CrIS temperature retrievals from NOAA Unique CrIS/ATMS Processing System (NUCAPS)—the operational retrieval algorithm for JPSS—depict the spatial extent of the coldest air very well compared to model reanalysis (Fig. 4)
- However, because typical flight levels are in regions just below the tropopause, there is a tendency for the satellite sounder to shift the coldest air (Fig. 5) and exhibit a warm bias in that region (Fig. 6)

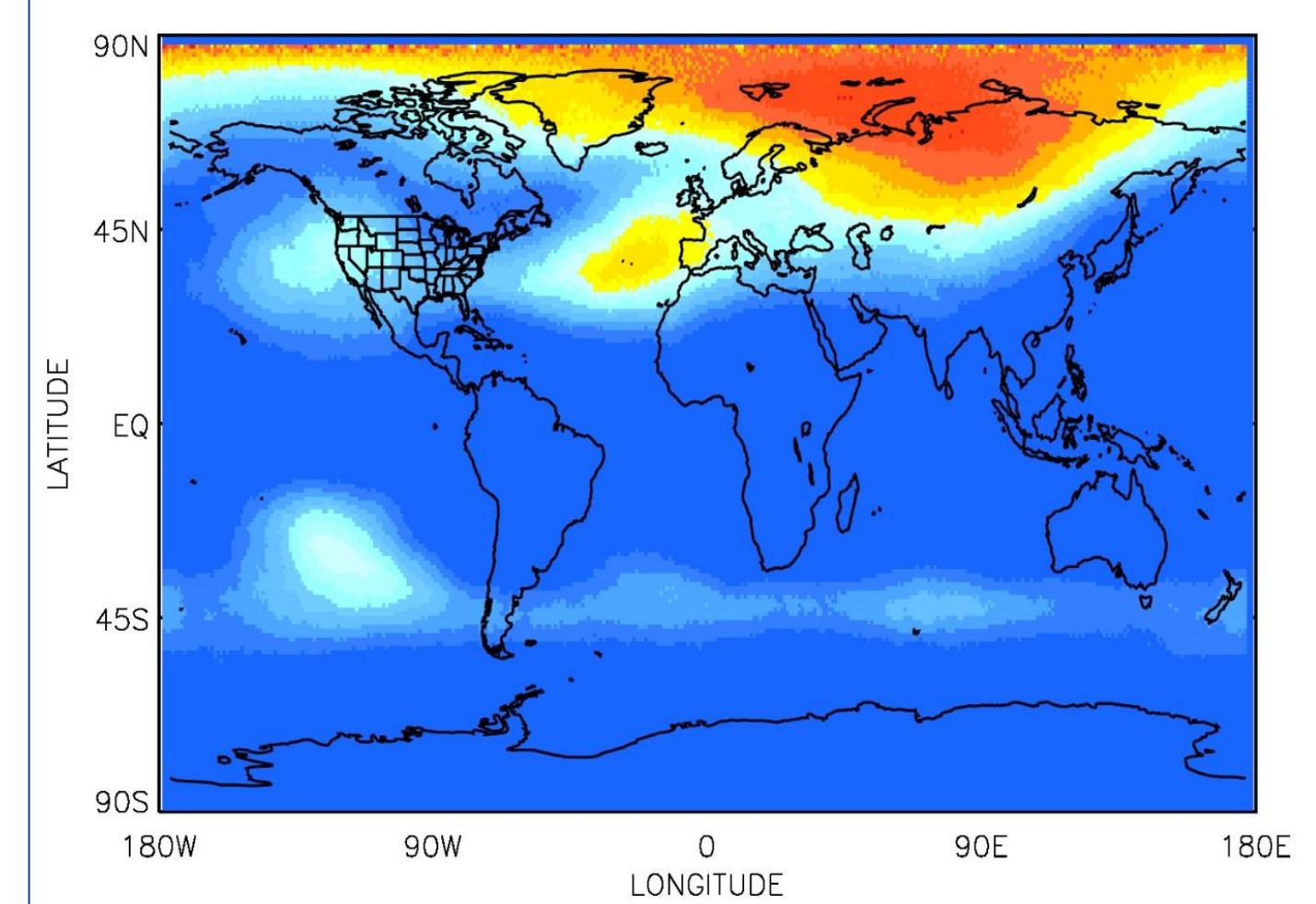


Fig. 3. Probability of observing $T \leq -60^{\circ}\text{C}$ in Atmospheric Infrared Sounder data at 200 hPa from January 2005 to January 2015.

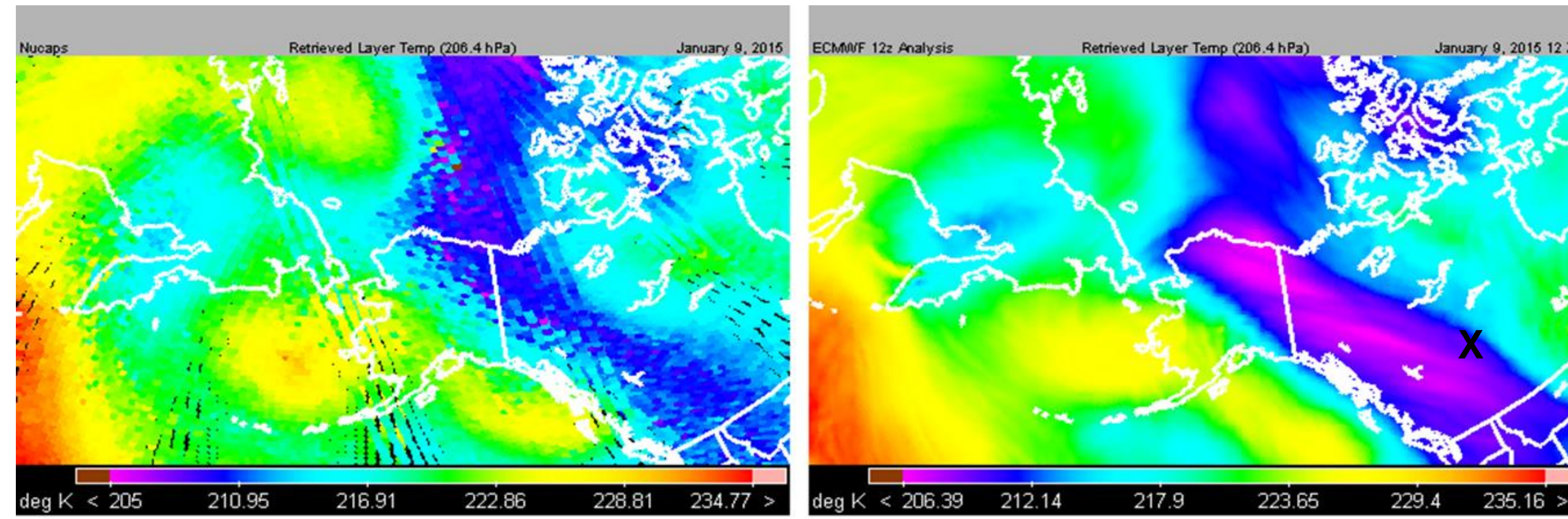


Fig. 4. 200 hPa NUCAPS soundings (left) and ECMWF 200 hPa reanalysis at 1200 UTC on 9 January 2015 during a CAA outbreak across eastern Alaska and western Canada. The "X" denotes the location of the sounding shown in Fig. 5.

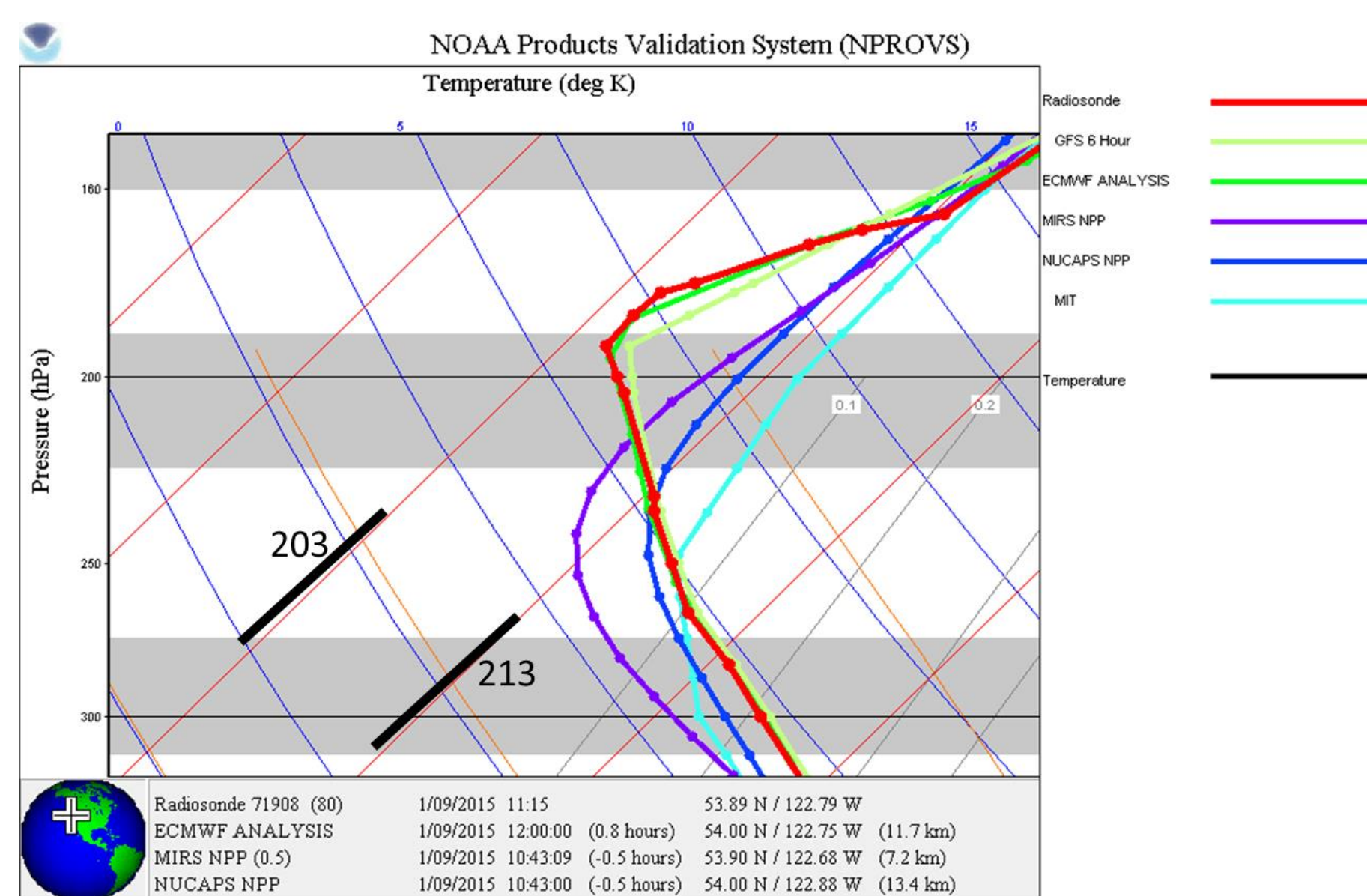


Fig. 5. Comparison of observed and modeled vertical soundings over western Canada in core of CAA ("X" in Fig. 4) at 1200 UTC on 9 January 2015. Note that coldest air in NUCAPS data (dark blue) is lower in the atmosphere and slightly warmer than observed by radiosonde (red).

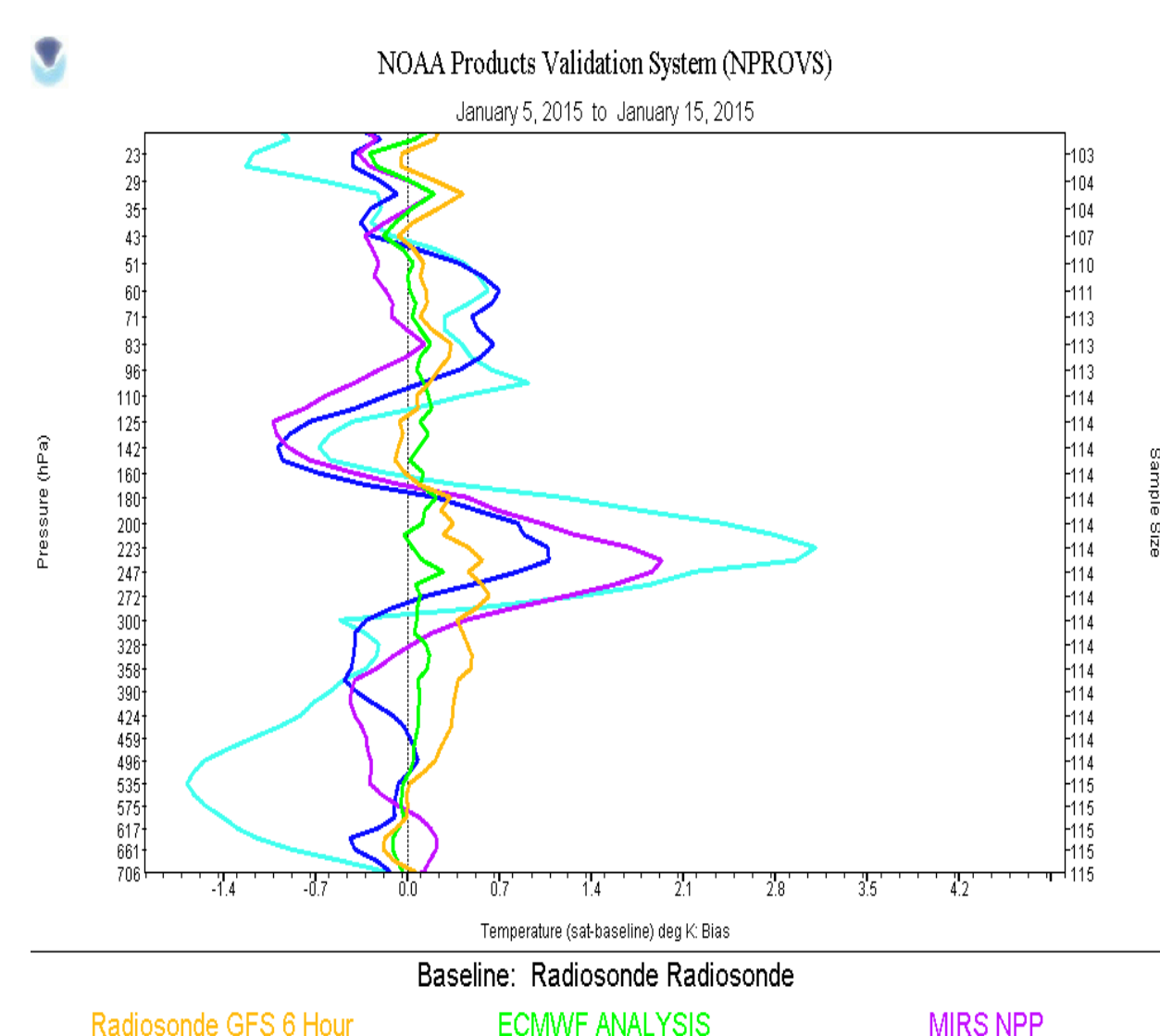
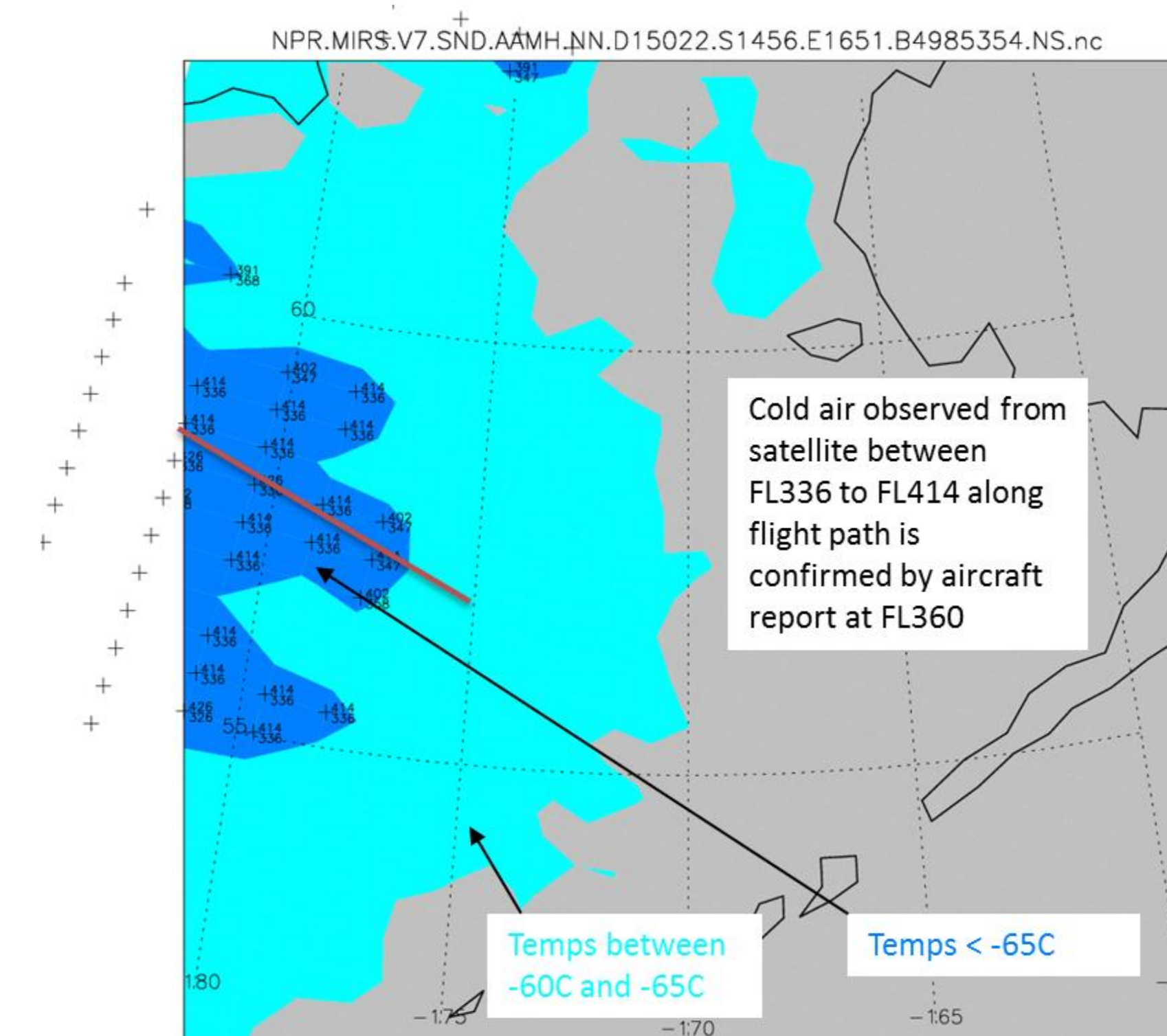


Fig. 6. Comparison of satellite and modeled sounding biases compared to all radiosondes in Alaska from 5 to 15 January 2015. Again, note warm bias at around 200 hPa in all datasets.

DEVELOPMENT OF VISUALIZATION OF CAA FOR AWIPS II

- Current implementation of NUCAPS as Skew-Ts in AWIPS II is difficult to use for detecting the extent of air masses as one has to click on lots of soundings and then synthesize that data to make decisions
- Forecasters at CWSU requested a gridded NUCAPS product in AWIPS II that will enable plan view plots with a color-curve enhancement that will flag CAA regions
- Visualization was developed based on web graphics created at CIRA (Fig. 7)
 - NOAA-18 Microwave Integrated Retrieval System (MIRS) determined region of temperatures less than -65°C between of 50 and 60°N latitude and west of 175°W longitude between FL336 and FL414
 - Aircraft reported temperatures at -65°C and -66°C from latitude/longitude $54^{\circ}\text{N}/175^{\circ}\text{W}$ to $56^{\circ}\text{N}/177^{\circ}\text{E}$ at FL360 at 1642z on 22 January
 - Most other aircraft were flying at FL330 or lower in that area
- Gridded HDF output from CIMSS *polar2grid* software has been converted to a GRIB2 format for visualization within the Volume Browser in AWIPS II (Figure 8)



FFAK20 KZAN 221521
ZAN MIS 03 VALID 221530-230330
...FOR ATC PLANNING PURPOSES ONLY...
FROM 700W HPB-45NW HPB-130N DUT-525W
SYA-700W HPB
COLD AIR ALOFT
TEMPS -65C OR LESS FM FL330-FL360. STNR.
NC.
CMW JAN 15

Fig. 7. Example of CAA visualization from CIRA website on which AWIPS II visualization is based (top). Cyan areas depict regions where satellite detects air below -60°C ; blue areas, below -65°C . Crosses represent location of individual retrievals with annotated top and bottom flight levels giving the vertical location of the cold ($< -65^{\circ}\text{C}$) air. Red line depicts a flight track that verified the 3D extent of the CAA shown by the satellite. Text is the CAA MIS issued by the CWSU for this event based on the aircraft report.

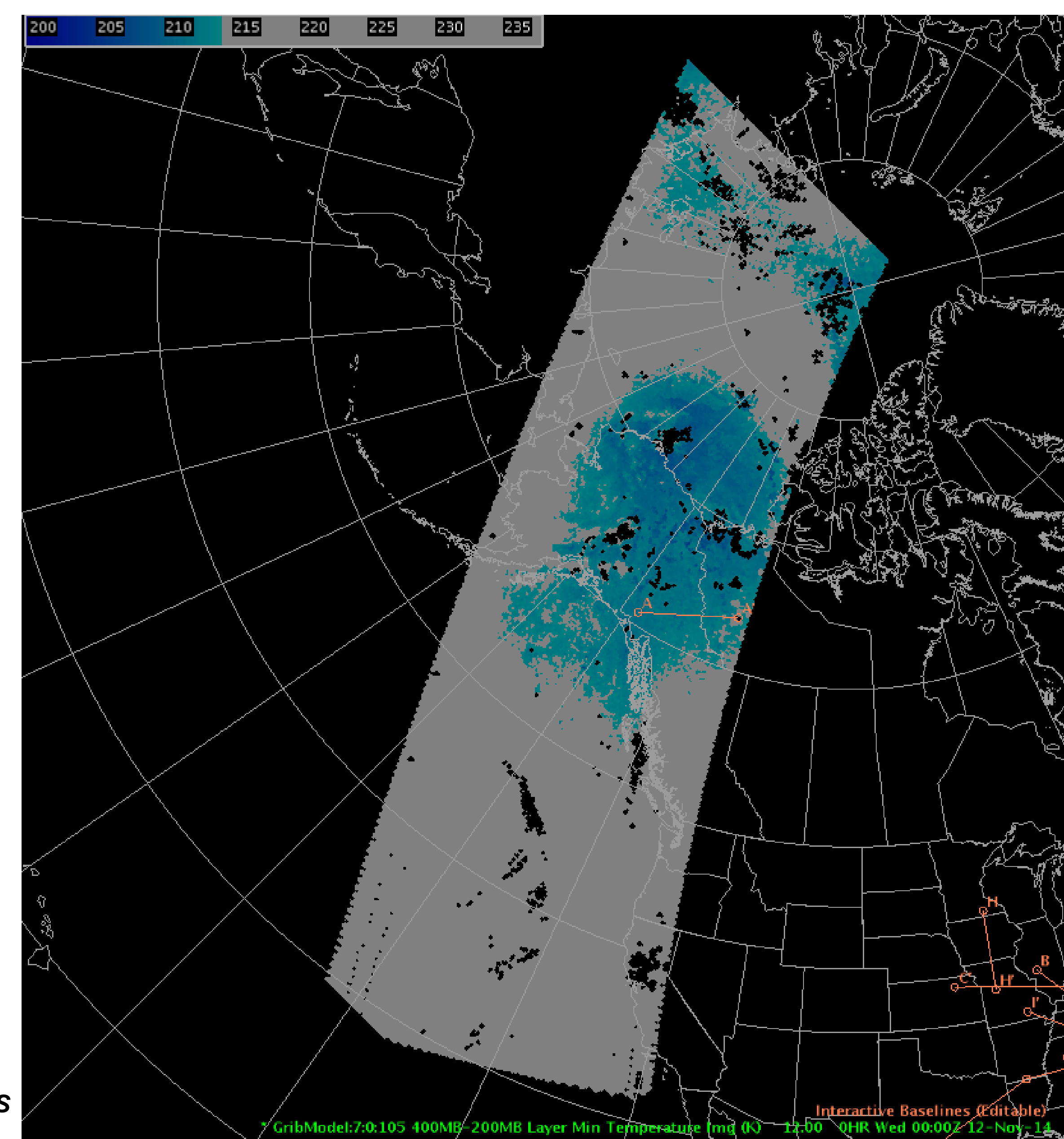


Fig. 8. CAA Visualizations in AWIPS II using sample 8-level University of Wisconsin/CIMSS Dual Regression gridded product from 12 November 2014. Here, the minimum temperature in a layer from 400 to 200 hPa is depicted using the same color curve as is shown in Fig. 7.

SUMMARY

- A collaborative effort between SPoRT, CIMSS, CIRA, GINA, and NOAA has produced quantitative analysis and unique visualization of real-time JPSS sounding products to aid decision makers in high latitude regions with the detection of cold air events that are known to be aviation hazards.

FUTURE WORK

- CIMSS to amend *polar2grid* software within CSPP to generate gridded NUCAPS soundings
- GINA to disseminate gridded NUCAPS to SPoRT for formatting to GRIB2 format and ingest into the AWIPS II systems at the Alaska CWSU
- CIRA to integrate gridded NUCAPS into suite of web graphics for the CWSU to include in public products
- Development of training to communicate CAA forecast challenge, sounder strengths and limitations, and use cases is underway
- Targeted assessment period planned for winter 2016 to evaluate the operational utility of this visualization

ACKNOWLEDGMENTS

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